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Effect of spraying dates with nano-zinc on some characteristics of quality, viability and emergence of maize

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Abstract

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A laboratory experiment was carried out in the Seed Technology Laboratory of the College of Agricultural Engineering Sciences – University of Baghdad (during 2021) with the aim to study the effect of nano-zinc concentrations and the dates of their addition on the quality, viability, and seed vigor characteristics of maize seeds. A factorial experiment was applied according to a completely randomized design (CRD) with three replications. The first factor represents the dates of spraying (the beginning of the male flowering stage, 50% female flowering, and the completion of female flowering) and its symbol (D1, D2, and D3) respectively, while the second factor was represented by zinc concentrations (0, 100, 200 and 300 mg L^{-1}). The results of the statistical analysis showed the significant effect of the dates of spraying nano-zinc in all the studied traits, the early date (D1) gave the highest average germination energy (94.50%), final count of germination (96.67%), radicle length (6.85 cm), plumule length (6.96 cm), fresh weight of the seedling (4.85 g), and the highest dry weight (2.23 g). The results showed the superiority of nano-Zn concentrations in most of the viability and seed strength traits for the studied traits, especially at the concentration of 300 mg L^{-1}, Which gave the highest average germination energy of 94.44%, radicle length of 7.07 cm, plumule length of 7.04 cm, fresh seedling weight of 5.86 g, and the highest dry weight of 2.83 g. It is concluded from this study that spraying at the beginning of flowering stage is the most responsive to spraying the nano-Zn element, and the concentration of 300 mg L^{-1} was distinguished in all viability characteristics and seed vigor.

Keywords: *Zea mays;* seed viability; seed germination; nano technology

Introduction

Agriculture is the mainstay of the economies of the third world, and maize is an important strategic crop for its use in many foods industries, and because of the inability to expand the cultivation of this crop with the limited land area and the lack of available water resources, which requires increasing the efficiency of the use of available water and various natural resources, and to avoid the deterioration of the soil that occurs due to the misuse of chemical fertilizers or the adoption of traditional methods in agriculture. Recently, researchers headed to the production of nano-fertilizers by encapsulating nutrients with nanomaterials. Nanotechnology has been described as one of the fastest spreading technologies at the global level, and it has been called the next technical revolution in various fields due to its great advantages (Lux, 2008).

Nanotechnology is concerned with the study of the componsiti,on, properties and manufacture of nanomaterials with a size ranging between 1-100 nanometers, as well as the applications of these materials in various industrial, medical and agricultural fields (Chinnamuthu & Boopathi, 2009).The advantage of this technology lies in the unique properties of these nanoparticles, as the size has no effect on the properties of materials up to the micrometer size, while these materials acquire new physical, chemical and biological properties when they are converted into nanosized sizes and here lies the unique properties of nanomaterials (Margulis & Magdassi, 2012). In addition to improving soil properties for water retention and production of nanofertilizers (Chhipa , 2017).

Micronutrient deficiencies are a growing concern in the world, leading to various health and social problems such as mental retardation, weak immune system and improper general health, because the zinc concentration in grains is inherently very low. Cultivation of grains in zinc-deficient soils further reduces zinc concentration. Therefore, it is not surprising that a high deficiency of zinc in humans occurs mostly in areas whose soils suffer mainly from a lack of available zinc. The use of zinc oxide nanoparticles with other fertilizers in soils that suffer from zinc deficiency leads to an improvement and efficiency of the use of elements and also increases the productivity of barley (Kale & Gawade, 2016). It was observed from the results of a study conducted by Prasad et al. (2012), to find out the effect of zinc oxide nanoparticles on the growth and development of the peanut crop, The peanut seeds were treated by soaking the seeds with different concentrations of nano zinc oxide, which are 400, 1000 and 2000 mg kg^{-1} by soaking the seeds and knowing its effect on seed germination, seedling growth, root growth, chlorophyll content and flowering. The results showed that the concentration of 1000 mg kg^{-1} led to an increase in both seed germination and seedling vigor. He indicated that zinc nanoparticles can be used as a source of zinc to reduce zinc deficiency in cereals (Munir et al., 2018). Nano zinc is used with urea in different doses and concentrations according to the crop. Its use led to an increase in the zinc content in the grains by more than the amount of zinc in traditional fertilizers, and an increase in the grain yield and the weight of 1000 grains. Accordingly, this study came to know the effect of the concentrations of zinc nanoparticles and the timing of spraying on plant yield and its components of maize crop. This study came with the aim of studying the effect of spraying with nano-zinc fertilizer and the dates of its addition on the vitality of maize seeds.

Materials and Methods

A laboratory experiment was carried out in the Seed Technology Laboratory of the College of Agricultural Engineering Sciences – University of Baghdad (during 2021), with the aim to study the effect of nano-zinc concentrations and the dates of their addition on the germination vigor characteristics of maize seeds. Maize seeds of Buhooth 106 were sown and the seeds were treated with zinc concentrations (0, 100, 200 and 300 mg L^{-1}). A factorial experiment was applied according to a completely randomized design(CRD)with three replications for each treatment.Nano zinc was prepared by dissolving 1 gm in 1 liter of water, then the quantities of 100, 200 and 300 ml were withdrawn and the solution was completed to 1 liter to prepare the above concentrations and we used distilled water as a control treatment. The seeds used in the experiment were taken from plants that were treated with three spraying dates (beginning of the male flowering stage, 50% female flowering and completion of female flowering) and symbolized (D1, D2, and D3), respectively.

Studied traits

Germination energy: The germination energy was calculated according to equation (Farooq et al., 2005) from calculating the percentage of germination on the fourth day after planting in relation to the total number of planted seeds, according to the following equation: GE = GP (4th day)/ TNST.

Final germination count, %: This test was carried out 11 days after placing the seeds in the germinator and the germination percentage was calculated by dividing the number of natural seedlings by the total number of seeds expressed as a percentage (AOSA, 2020).

Radicle length: The length of the radicle was measured after separating it from the seed junction point and measured using a ruler (Hampton & Tekrony, 1995).

Plumule length, cm: was measured after separating it from its connection point with the embryonic peduncle using a ruler for ten seedlings (Hampton & Tekrony, 1995).

Seedling fresh weight, mg: Ten seedlings were taken from each experimental unit randomly and weighed with a sensitive electric scale and the average fresh weight was extracted by dividing the total seedling weights by their number.

Seedling dry weight, mg: The embryonic axonal parts (Radicle and Plumule) were placed in perforated bags in an electric oven at a temperature of 80ºC for a period of 24 hours, then weighed with a sensitive electric scale and extracted the dry weight rate by dividing the total weights of the seedlings by their number.

Results and Discussion

Germination energy, %

The results show that the early spraying time at the beginning of the male flowering stage was significantly superior by giving it the highest average germination energy of 94.50, followed by the second time, i.e., spraying at the 50% stage of female flowering with an average of 90.83 with no significant difference the date of completion of female flowering (Table 1).

Table 1. Effect of spraying time with different concentrations of zinc nanoparticle on the germination energy

Zn concentration mg L^{-1}	(D) Date			Mean Zn	
	D1	D2	D3		
0	89.33	80.67	80.00	83.33	
100	94.00	90.67	90.00	91.56	
200	96.67	95.33	94.67	95.56	
300	98.00	96.67	94.67	96.44	
LSD_{Z*D}	3.323			LSD_Z	1.919
Mean dates	94.50	90.83	89.83		
LSD_D	1.662				

The results also showed that the increase in the concentration of zinc nanoparticles led to a clear increase in the germination energy. The control treatment, the germination energy was 83.33, while it increased to 96.44 at the concentration of 300 mg L^{-1} of nano-zinc concentration with no significant differences from the concentration of 200 mg L^{-1}.The reason for this increase may be due to the increase in the zinc content in the grains themselves and to the fact that zinc nanoparticles have helped the seeds absorb water, increase some enzymes necessary for germination and reduce free radicals, and then increase the germination rate. This is consistent with what was mentioned (Prasad et al., 2012; Munir et al., 2018).

The results also show a significant interaction between the spraying dates and the concentration of nano-zinc, as the combination (first date × 300 mg L^{-1}) gave the highest average of 98.00 with no significant difference from other combinations (D1 × 200 mg L^{-1}) or (D2 × 300 mg L^{-1}).

Germination percentage in the final count of the standard laboratory germination test:

The results showed that the early spraying date at the beginning of the male flowering stage was significantly superior by giving the highest average percentage of germination in the final count (96.67%), followed by the second spraying date (in the stage of 50% female flowering) with an average of 94.17% with no significant difference with final date D3 (Table 2).

Table 2. Effect of spraying time with different concentrations of zinc nanoparticle on the percentage of germination in the final count in the standard laboratory germination assay

Zn concentration mg L^{-1}	(D) Date			Mean Zn	
	D1	D2	D3		
0	90.67	84.67	89.33	88.22	
100	97.33	94.00	95.33	95.56	
200	98.67	98.67	97.33	98.22	
300	100.00	99.33	93.67	97.67	
LSD_{Z*D}	N.S			LSD_Z	2.517
Mean dates	96.67	94.17	93.92		
LSD_D	2.180				

The results showed that increasing the concentrations of nano-zinc gave a gradual increase in the percentage of germination, after it was 88.22% in the control treatment, the germination percentage in the final count reached the highest percentage at the concentrations 200 and 300 mg L^{-1} with an average of 98.22% and 97.67%, respectively. There was no significant interaction between the two factors of the study in the percentage of germination in the final count.

Radicle length, cm

The results show that the date of the first spraying at the beginning of the flowering stage was significantly superior by giving the highest average root length of 6.85 cm, followed by the date of the second spraying (in the stage of 50% female flowering) with an average of 6.19 cm with no significant difference with the last date of 5.87 cm (Table 3).

Table 3.Effect of spraying time with different concentrations of zinc nanoparticle on the radicle length

Zn concentration mg L^{-1}	(D) Date			Mean Zn	
	D1	D2	D3		
0	5.00	4.43	4.47	4.63	
100	7.17	6.70	5.97	6.61	
200	7.77	6.63	6.27	6.89	
300	7.45	6.98	6.78	7.07	
LSD_{Z*D}	N.S			LSD_Z	0.493
Mean dates	6.85	6.19	5.87		
LSD_D	0.427				

The zinc nanoparticles showed a significant superiority in all its concentrations over the control treatment in the radical length. As the increase in zinc concentrations led to an increase in the average length of the radicle until it reached its highest average of 7.07 cm at the concentration of nano-Zn 300 mg $L^{-1}$with no significant difference with the concentration of 200 mg L^{-1} (Table 3), and the result agrees with (Laware & Raskar , 2014).

Plumule length, cm

The results show that the first and second dates gave the highest average plumule length of 6.96 and 6.49, and there was no significant difference between them, with a significant difference from the third date, which gave the lowest mean of 5.90 cm (Table 4).The results also show that the increase in nano-Zn concentrations gave a gradual increase in the length of the plumule of maize. the control treatment was 5.19 cm, and the average length of the plumule reached the highest length at concentration and 300 mg L^{-1} with an average of 7.04 cm. The results are consistent with what was concluded (Rawat & Pradeep , 2018) in the role of nano-zinc in increasing the length of the plumule. There was no significant interaction between the study factors in the average length of the plumule.

Table 4. Effect of spraying time with different concentrations of zinc nanoparticle on the plumule length

Zn concentration, mg L^{-1}	(D) Date			Mean Zn	
	D1	D2	D3		
0	5.50	5.07	5.00	5.19	
100	7.18	6.67	6.13	6.66	
200	7.47	7.03	6.23	6.91	
300	7.68	7.20	6.23	7.04	
LSD_{Z*D}	N.S			LSD_Z	0.491
Mean dates	6.96	6.49	5.90		
LSD_D	0.425				

Seedling fresh weight, g

The results indicate that the first and second spraying dates with nano-zinc were significantly superior with the highest average fresh weight of maize seedlings of 4.85 and 4.50 g, with no significant difference between them (Table 5), with a significant different from the third date which gave the lowest average weight of 3.85 g.

The results show that increasing the concentrations of nano-Zn gave a gradual increase in the average of seedling fresh weight, reached the highest weight at concentrations 200 and 300 mg L^{-1} with an average of 5.31 and 5.86 g, respectively. While the control treatment recorded the lowest seedling fresh weight of 1.39 g. There was no significant interaction between the study factors in the average seedling fresh weight.

Table 5. Effect of spraying time with different concentrations of zinc nanoparticle on the seedling fresh weight

Zn concentration mg L^{-1}	(D) Date			Mean Zn	
	D1	D2	D3		
0	1.50	1.58	1.10	1.39	
100	5.53	4.93	4.67	5.04	
200	5.80	5.53	4.60	5.31	
300	6.57	5.97	5.03	5.86	
LSD_{Z*D}	N.S			LSD_Z	0.622
Mean dates	4.85	4.50	3.85		
LSD_D	0.539				

Seedling dry weight, g

The results indicate that the date of the first spraying with nano-zinc was significantly superior with highest average seedling dry weight of 2.23 g, with significant difference from the last date with the lowest seedling dry weight of 1.68 g (Table 6). The results show that increasing the concentrations of nano-Zn gave a gradual increase in the average weight of seedlings dry weight, reached the highest weight at concentrations 200 and 300 mg L^{-1} with an average of 2.62 and 2.83 g, respectively. While the control treatment recorded the lowest seedling dry weight of 0.64 gm. The results agree with (Rawat & Pradeep, 2018). Whereas, for the interaction, it appears that spraying the concentration 300 mg L^{-1} in the first and second dates gave the highest value of the interaction, which amounted to 3.27 and 3.37 respectively (Table 6).

Table 6. Effect of spraying time with different concentrations of zinc nanoparticle on the seedling dry weight

Zn concentration mg L^{-1}	(D) Date			Mean Zn	
	D1	D2	D3		
0	0.73	0.67	0.53	0.64	
100	2.10	1.80	1.67	1.86	
200	2.80	2.63	2.43	2.62	
300	3.27	3.17	2.07	2.83	
LSD_{Z*D}	0.120			LSD_Z	0.088
Mean dates	2.23	2.07	1.68		
LSD_D	0.100				

Conclusions

It was concluded from this study that spraying zinc element in the beginning of flowering stage is better than the following stages, which was reflected in improving the vital characteristics and quality of maize seeds and the strength of their seedlings. It is noticeable the response of the seeds to treatment with nano-zinc, especially at the higher concentration used in the study, which gives an indication of the possibility of the crop responding to higher concentrations of this element.

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